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The stock status of Atlantic salmon (*Salmo salar* L.) in Big Brook (Michaels River), Labrador, 2000

État du stock de saumon atlantique (*Salmo salar* L.) du ruisseau Big (rivière Michaels), au Labrador, en 2000

By / Par

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ABSTRACT

The status of the Atlantic salmon (*Salmo salar* L.) stock in Big Brook (also known as Michaels River), Labrador in 2000 was determined using counting fence data, samples collected in the angling fishery, and records of angling mortalities. The stock assessment was conducted in relation to the closure of the Atlantic salmon commercial fishery in Labrador in 1998. In 2000, total returns to Big Brook, adjusted for a non-operational period of the counting fence, were 982 small and 151 large salmon. Small and large salmon made up 87% and 13%, respectively of returns to the river. The number of spawners adjusted for angling mortalities were 878 small and 140 large salmon. The egg deposition required for conservation for Big Brook used only as a reference level in Labrador is 5.294 x 103 eggs using information from a river survey conducted by Murphy (1973) and the salmon conservation requirement of 240 eggs per m2. In 2000, the proportion achieved of the conservation egg requirements was 42% (95th confidence intervals 34 to 61%). Although the percent of conservation requirements met has increased over values in 1997 and 1999, the percent of conservation requirements met remains low.

RÉSUMÉ

L'état du stock de saumon atlantique (*Salmo salar* L.) du ruisseau Big (aussi connu sous le nom de rivière Michaels), au Labrador, en 2000, a été déterminé d'après des données recueillies à une barrière de dénombrement, des échantillons des prises sportives et des renseignements sur la mortalité par pêche sportive. L'évaluation du stock a été réalisée dans le contexte de la fermeture de la pêche commerciale du saumon atlantique au Labrador en 1998. En corrigeant pour tenir compte d'une période où la barrière de dénombrement ne fonctionnait pas, on estime qu'en 2000, 982 petits et 151 gros saumons ont remonté dans le ruisseau Big, soit respectivement 87 % et 13 % de la remonte dans ce cours d'eau. Le nombre de géniteurs corrigé pour tenir compte de la mortalité par pêche sportive était de 878 petits et 140 gros saumons. D'après l'information recueillie au cours d'un relevé du cours d'eau effectué par Murphy (1973) et les 240 œufs par m2 nécessaires pour répondre aux besoins de conservation du saumon, la ponte requise pour satisfaire à ces besoins dans le ruisseau Big (utilisée seulement comme niveau de référence au Labrador) se chiffre à 5,294 x 103 œufs. En 2000, ces besoins ont été comblés dans une proportion de 42 % (intervalle de confiance de 0,95 allant de 34 à 61 %). Ce pourcentage a augmenté par rapport aux valeurs de 1997 et de 1999, mais il reste faible.

INTRODUCTION

Big Brook (also known as Michaels River) is located in northern Labrador in Salmon Fishing Area 1 (SFA 1) and flows into Byron Bay near Red Rock Point just to the north of Cape Rouge at 54^0 41' N 57^0 47' W (Anderson 1985) (Fig. 1). The mouth of the river is protected by a high, sandy beach, which forms a lagoon that is approximately 1.5 km long. Big Brook has a drainage area of 793 km^2 and a total stream length (including measured tributaries) of 200 km (Murphy 1973). Exploitation of fish stocks takes place from a sports fishing camp on the river, from fly-in anglers and from a nearby aboriginal food fishery. The entire watershed is accessible to migrating fish. Anadromous Atlantic salmon (*Salmo salar* L.), Arctic charr (*Salvelinus alpinus* L.), and both sea-run and resident brook trout (*Salvelinus fontinalis* L.) have been reported in the system (Anderson 1985). Stock status has been determined previously from counting fences operated on Big Brook in 1997 and 1999 (Reddin and Short 1998; Reddin and Short 2000).

In 1992, several major changes were introduced to the management of Atlantic salmon in Newfoundland and Labrador. A five-year moratorium was placed on commercial salmon fishing in the island portion of the province, quotas for the Labrador commercial fishery, first introduced in 1990, were reduced and a voluntary retirement of commercial salmon licences was instituted for all of the province. In 1998, the commercial fishery in Labrador was closed and fishermen were offered a buyout which most accepted. In 1999 and 2000, a food fishery of 10 tonnes was available for members of the Labrador Inuit Association including catches in Lake Melville, which is also in SFA 1. The West Greenland commercial salmon fishery which was closed for the 1993 and 1994 fishing seasons but was open again in 1995-97. Although no tagging studies have documented the distribution of Big Brook salmon at sea, some Big Brook multi-sea winter salmon may be caught in the Greenland fishery similar to other Labrador stocks (Pratt et al. 1974).

In the angling fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each SFA. The quota was assigned for an entire SFA and was not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught. In 1994, quotas for the angling fishery were eliminated. In place of quotas, for Labrador, the season bag limit for retained salmon was lowered from eight to six fish, only two of which could be large salmon. In 1995 and 1996, the season bag limit for the angling fishery remained at six fish but only one large salmon could be retained. In 1999 and 2000, the angling fishery was restricted to a seasonal limit of four salmon retained, one of which could be large, and a daily limit of four salmon hooked-and-released. In 1999, use of barbless hooks became mandatory.

In 2000, a salmon assessment project was conducted on Big Brook. The main focus of this project, conducted in collaboration with Atlantic Sports Fishing Inc. (Mr. W. Bennett operator of the outfitting lodge), was to assess the population of salmon in a northern Labrador river. The first counting facility to be installed in a river in SFA 1 in recent years was on Big Brook in 1997. Thus, Big Brook is one of the few Atlantic salmon rivers in Labrador for which quantitative data are available. In this paper, the stock status of the Big Brook salmon population in 2000 is examined.

METHODS

Angling and commercial fisheries data

Catch and effort data from the angling fishery in Big Brook were collected by Department of Fisheries and Oceans (DFO) enforcement staff in conjunction with angling reports submitted by commercial sports camp operators and processed by DFO Science Branch. DFO angling statistics for Big Brook include salmon caught at the fish camp and by non-camp anglers. In 1997 and 1999, angling catches for Big Brook took place below the counting fence where the majority of salmon were reported to have been caught (pers. comm., Mr. J. Small). For 2000, records were kept of those salmon angled above and below the counting fence. Procedures for the collection and compilation of angling fishery data are described by Ash and O'Connell (1987).

In 1994, a new system, viz. the License Stub Return System (LSRS) was initiated for collecting angling statistics in Newfoundland and Labrador. It is based on attaching to the provincial angling licence a detachable stub upon which the angler can record details of where and when he/she fished, and the numbers of salmon caught and released (O'Connell et al. 1998). Because of concerns over a lack of comparability of DFO angling statistics and the LSRS data, DFO data will continue to be used for Labrador and in particular for Big Brook.

For purposes of separating 2SW salmon from 1SW salmon in angling and other fisheries, small salmon are defined as those salmon less than 63 cm and will be mainly 1SW (grilse) in age. Large salmon are those salmon equal to or greater than 63 cm and will be mainly 2SW and older in age. These size definitions are used for biological sampling as well.

Adult salmon counts

COUNTING TECHNIQUES

Between 12 July to 15 July, 2000, a counting fence was constructed approximately 3 km upstream from the mouth of Big Brook (Fig. 2). This site was about 1 km upstream from the site used in 1997 and about 100 m upstream from the site used in 1999. The fence was moved slightly upstream in 2000 to improve the movement of salmon and shorten the length of fence required to span the river. Upstream migrating adult salmon were enumerated from 16 July to 12 August 2000. The counting fence consisted of 36 sections (each 3 m long) which were installed as described in Anderson and McDonald (1978). The fence was constructed of conduit and channel iron, supported by steel posts and 5 cm x 15 cm wooden supports similar to other portable counting fences used in Newfoundland and Labrador. The fence was operated with every conduit in place so that smaller charr and sea trout if present would be included in the counts.

Once the counting fence was completely installed, enumeration was done by manually releasing and counting salmon through a standard wooden fish trap. Distinction between large and small salmon was made by comparison to a known measure placed in the bottom of the fish trap. Large salmon were defined as those salmon with a fork length greater than or equal to 63 cm and small salmon are those less than 63 cm. All other fish species encountered in the trap were also enumerated.

ADJUSTED COUNTS

In 2000, the counting fence was non-operational prior to 16 July and after 12 August. Because salmon were sited in the river outwith this operational period, the counts required adjusting to include all salmon entering the river. Because run timing was very different in 2000 compared to the other years for which data was available, the only suitable was through comparison with the run timing to English River. During this non-operational period, salmon counts were adjusted proportionately to the counts at English River before and after the operational period. As a test of this technique, comparison was made between counts at English River and Big Brook for the same period in 1999, which is the only other year when counts were available for both systems.

Unrecorded Mortalities

Complete understanding of all life history factors and numbers of fish achieving each life stage including mortalities is an important part of any stock assessment (Ricker 1975). Mortalities due to fishing, but not recorded as part of the catch statistics, have been defined as non-catch fishing mortalities by Anon. (MS 1980) and Ricker (1976). Non-catch fishing mortalities could include fish killed due to illegal and legal fishing activities. In 2000, legal fishing mortalities for salmon in Labrador included catches in native food and angling fisheries. It is possible that some Big Brook origin salmon were taken in nets set near coastal communities.

Another potential source of non-catch fishing mortality is from hook and release angling. Booth et al. (1995) and Brobbel et al (1996) have studied the effects of hook & release angling on the delayed mortality of 'bright' or returning salmon. Dempson et al. (1998) summarized all of the hook and release studies available. These studies indicated that the length of time spent in fresh water and water temperature at time of exhaustive exercise such as angling, have an effect on mortality rates. Fish that have spent longer periods of time in freshwater appear to have a lower mortality rate than those that have recently entered freshwater. Also, higher water temperatures increased the mortality rate. They concluded that mortality due to catch & release in a controlled environment was about 12%, although the sample size was small (n=25). Therefore, we have included an estimate of 10% mortality of caught and released fish in our calculations of total river returns and spawning escapement.

Exploitation rates

Exploitation rates for the angling fishery were determined as the number of salmon reported to have been retained by the angling fishery divided by the total number of salmon entering the river adjusted for salmon caught below the counting fence.

Biological characteristics

Biological characteristics of adult Atlantic salmon were obtained by taking samples of angling catches. These data were collected at the Big Brook (Michaels River) fishing lodge in 1997, 1999, and 2000 with the assistance of fishing guides after instruction by DFO technical staff. Information on fork length, weight, sex, and scales were collected. Samples are adequate to define the characteristics of the angling catch as most of the salmon caught in the angling fishery were sampled. Dates the samples were taken ranged from 7 July to 15 August, 1997, 11 – 26 July, 1999 and 16 July to 10 August, 2000.

Fecundity values used for Big Brook salmon were from Sand Hill River the only river in Labrador where fecundity has been measured. Fecundity is determined as number of eggs per kg of whole weight or number of eggs per cm fork length. The ovaries were collected from the angling fishery on Sand Hill River in 1994 and 1995 resulting in mean total egg count of 3,808 eggs (n=96) for small salmon and 5,096 eggs (n=23) for large salmon (O'Connell et al. 1997). Relative fecundity for small salmon from Sand Hill River was 1,998 eggs per kg and for large salmon 1,094 eggs per kg. In terms of fork length, relative fecundity was 68.2 eggs per cm for small salmon and 67.5 eggs per cm for large salmon. In the absence of samples from Big Brook, the Sand Hill River fecundity values were used.

Total river returns, spawning escapement, and egg deposition

TOTAL RIVER RETURNS

Total river returns (TRR) were calculated separately for small and large salmon as follows:

$$TRR = FC + RC_b + HRM_b$$

where,
FC = adjusted fish count at counting fence
RC_b = angling catch below counting fence
HRM_b = hook & release mortalities evaluated as 10% of hook & released fish the below counting fence.

SPAWNING ESCAPEMENT

Spawning escapement (SE) was calculated as the difference between the number of fish returning to the river (TRR) minus the angling catches of retained salmon above and below the fence (AC) minus 10% of hook and released salmon above the counting fence.

$$SE = TRR - (AC_a + HRM_a) - (AC_b + HRM_b)$$

where,
AC_a = angling catch above the counting fence
HRM_a = hook & release mortalities evaluated as 10% of hook & released fish above the counting fence.

EGG DEPOSITION

Egg deposition (ED) summed from eggs deposited by small and large salmon was calculated separately for small and large salmon as follows:

$$ED = SE \times PF \times RF \times FL$$

where,
SE = number of spawners
PF = proportion of females
RF = relative fecundity (No. of eggs per cm)
FL = mean fork length of female salmon

Accessible parr-rearing habitat

The entire watershed of Big Brook is accessible to migrating Atlantic salmon (Anderson 1985). Big Brook has a drainage area of 793 km^2 (Murphy 1973) which for descriptive purposes was divided into three sections by Peet (1971). The first section, from the mouth of the river to Lake Michael, includes the lower 40 km of the river. Channel widths in this section range from 25 to 50 m, and bottom substrates vary among boulder, rubble, and gravel. There are four tributaries with ideal juvenile salmon habitat entering the river in this section. The second section referred to by Peet (1971) stretches km 40 to km 53 and is made up of Lake Michael and its tributaries. None of the tributaries of Lake Michael were surveyed by Murphy (1973) and are not included in the habitat estimate. The river above Lake Michael, the third section referred to by Peet (1971), averages 18 m in width and meanders over flat, barren terrain. None of the small tributaries were surveyed in this section either; although, the main stem is included in habitat estimates (Fig. 2). From his survey in 1972, Murphy (1973) recorded a total of 22,059 rearing units on the main stem and lower tributaries (Anderson 1985). Lake Michael is 2,589 hectares but is not included in parr-rearing habitat as it is unknown if parr rear in lake habitat in northern Labrador (SFA 1) rivers. The tributaries and ponds draining into and above Lake Michael on the main stem were also not included in the estimate of parr-rearing habitat.

Conservation Requirements

The minimum egg deposition requirement for conservation in Big Brook (SFA 1) was derived using egg deposition rates of 240 eggs per 100 m^2 for fluvial parr-rearing habitat (Elson 1957; 1975). Although these values may be habitat and river specific for river systems from which they were derived, they represent the best available data and are used as a general baseline for determining stock status of Big Brook. Biological characteristics used to calculate the conservation requirements in terms of eggs are from data collected in 1997 and 1999-2000. Conservation requirements were converted to numbers of fish according to the method described in Reddin (1998).

Environmental data

During field operations, environmental data were collected at the fence site. Water temperatures were recorded by Hugrun thermograph set at 1 m from the surface at the fence site. Cloud cover, relative water levels, weather conditions and air temperatures were also recorded.

Analysis of risk

The accuracy of egg depositions and percent of egg conservation requirements met is very important as it measures the status of the salmon stock in Big Brook. Accuracy was investigated through a simulation exercise which investigated the variability around several key parameters and the effect of this variability on egg deposition rates. In the section on egg depositions, only the numbers of small and large salmon counted at the fence during its operational period in 2000 were known with certainty. Total returns to the river were estimated from the fence count plus an adjustment to account for the period of non-operation of the counting fence. To account for this and some of the uncertainty in other parameter values used to determine potential egg deposition and percent of conservation requirement met, we assumed a range of values for each parameter used to estimate egg deposition and percent of conservation requirements met. Thus,

relative fecundity and fork length were set to vary at ±10%, spawning escapement was set to vary at ±20%, and proportion female at ±30%. Egg deposition and percent of conservation requirement met were calculated using 5000 realisations from a uniform distribution.

RESULTS

Angling fishery data

The DFO angling catch statistics for Labrador are largely based on data collected by angling camps. DFO data for Big Brook in 2000 indicated a retained catch of 89 small salmon and 11 large salmon. Also, 123 small salmon and 3 large salmon were hooked and released (Table 1). Almost all of the fishing effort for this system comes from the fishing lodge at the mouth of the river. Some effort does occur from fishers who fish the upper part of Big Brook and are not guests at the lodge. In 2000, camp records indicated that 2 small salmon were retained and 1 released above the counting fence.

Adult salmon counts

In 2000, a total of 625 small salmon and 110 large salmon were counted through the fence at Big Brook while the fence was operational (Table 2). There were salmon observed in the river before and after the operational period of the fence and thus the 2000 counts require correction to reflect the entire run. Salmon runs in 2000 over most of Labrador began earlier and lasted longer in 2000 compared to what had been the case in the years immediately preceding (Reddin et al. 2001). Thus, using 1997 and 1999 counts and their distributions from Big Brook to correct the 2000 counts would be highly misleading. A correction factor can be derived from English River, a river of about 328 km^2, which is 100 km to the north of Big Brook in Kaipokok Bay near the community of Postville. Correction factors defined as the proportion of salmon returning to the river inside the 16 July to 12 August period were 0.7384 for small salmon and 0.80 for large salmon. Because the number of salmon returning to the counting fence at English River are total returns with no angling removals downstream from the fence, correction factors should be applied to Big Brook returns including angling removals downstream from the fence. A test of this technique using known returns to English River and Big Brook in 1999, the only other year of available data for both rivers, indicates corrections were 98% and 107% of the actual counts for small and large salmon, respectively. This suggests that this technique applied to returns in 2000 may be suitable; although without a longer time series its accuracy is unknown.

In 2000, the total returns to Big Brook after adjustment for salmon angled below the counting fence and for the non-operational period was derived as follows:

Source	Small	Large	Total
Fence count	625	110	735
Angling retained below counting fence	88	11	99
Angling H&R at 10% below counting fence	12	0	12
Subtotal	**725**	**121**	**846**
Adjustments			
Factor	*/0.7384*	*/0.8000*	
Number	257	30	287
Total	**982**	**151**	**1,133**

In conclusion, there were 982 small and 151 large salmon adjusted to include returns over the entire season estimated to have returned to Big Brook in 2000. Thus, the 2000 returns consisted of 87% small salmon and 13% large salmon and angling catches consisted of 94% small and 6% large salmon, respectively.

Exploitation rates

The DFO statistics for the catch in the angling fishery, above and below the fence, were 90 small and 11 large salmon retained and 123 small and 3 large salmon hooked and released.

Exploitation rates in the angling fishery in 1997 and 1999-2000 are as follows:

Year	Small Retained	Small Released	Large Retained	Large Released
1997 (DFO)	13.8	6.0	1.9	1.0
1999 (DFO)	6.2	5.2	6.7	4.6
2000 (DFO)	9.2	12.5	7.3	2.0

In 2000, total mortality from the angling fishery on Big Brook including 10% for mortalities of hooked and released salmon was 10.4% for small salmon and 7.5% for large. Comparable numbers from 1997 were 14.3% for small and 1.9% for large and for 1999 were 6.7% for small salmon and 7.2% for large. Thus, mortality rate on small salmon has increased from 1999 but declined from 1997 values and for large has increased from 1997 to 2000.

Biological Sampling

In 2000, 75 adult salmon were sampled from the angling fishery. Mean fork length (FL) of the grilse was 55.2 cm (SD=2.56, n=36) and mean whole weight (WW) was 1.95 kg (SD=0.07, n=2) (Table 3). Mean fork length of two-sea winter virgin salmon was 78.3 cm (SD=2.93, n=8) and mean WW was 4.89 kg (SD=0.79, n=4). There were no repeat spawners in the sample.

Freshwater (river) age information is available from 41 salmon and is presented along with other biological characteristics information in Table 3. It indicates that 64% of the adults have a river age of 4 and 5 years. The modal smolt age is 4 years. There are not enough samples to adequately test whether the freshwater ages of small and large (or grilse and 2SW salmon) are significantly different statistically; however, in the 2000 samples small salmon are mainly 4 years while large salmon are 5 years.

The sea ages of the samples are 82% grilse and 18% virgin 2SW salmon.

The percentage of female salmon sampled from the angling fishery in 2000 was 14% (n=51) for small salmon. The large salmon were 90% (n=10) female (Table 3). The mean weight and fork length for small salmon was 1.95 kg (SD=0.07, n=2) and 54.8 cm, respectively (SD=2.68, n=65). For large salmon, comparable lengths and weights were 4.89 kg (SD=0.79, n=4) and 79.1 cm (SD=4.42, n=10) (Table 3).

The river age distribution of salmon in Big Brook appears to be changing to younger fish (Table 4). In 2000, there were 12% river age 3 small salmon and 14% river age 3 large salmon; whereas, in 1997, small salmon consisted of 3% river age 3 salmon and 0% in 1999 for both small and large salmon. The combined 1997 and 1999-2000 river age distribution of returning adult salmon of both sizes is dominated by 4-, 5- and 6-year olds (Table 4). In 1997, there were more 6-year olds on a proportionate basis while in 1999, 5-year olds dominated in small salmon. In 1999, small salmon were predominately 5-year old while large salmon were 4-year old. Small sample sizes precluded being definitive about changing river age in the samples.

BIOLOGICAL CHARACTERISTICS FOR ASSESSMENT

The available samples are adequate to represent the angling fishery but due to the short duration of time during which they were collected compared to returns to the river, the samples may not be representative of the population in Big Brook. This may be especially so in 2000 where the run into rivers was extended over almost 4 months. Also, samples that were sexed are too low in number to adequately define sex ratios. The sex ratio in particular for small salmon shows a low ratio of male salmon which is low compared to other rivers in Labrador and in part may have been due to the distribution of samples over the run. Samples were taken from angled salmon (only retained) and thus come from that period when the angling fishery was operational rather than being obtained over the entire run. Consequently, a proportion of 0.5 female for small salmon and 0.8 for large salmon was used in the assessment similar to Sand Hill River (Reddin et al. 1995) which also has a MSW salmon component (Table 5).

Analysis of variance was used to compare mean fork lengths of salmon captured by angling and sampled in 1997 and 1999-2000. Overall model had an R^2 of 0.90. Year effects were significant at less than 5% ($F_{2,185}$=13.4, P<0.0001) as were size effects ($F_{1,185}$=921.8, P<0.0001) while fork lengths of males and females were not significantly different from each other ($F_{2,185}$=1.96,

P=0.14). This suggests that the assessment should be done with separate values for each year and for large and small salmon and that samples from male and female salmon can be combined.

Parameter values of small and large salmon used for the determination of egg deposition include mean fork lengths and proportions female. In 1997, the best estimate of mean fork length of small salmon (male and female included) is 54.0 cm for small salmon and 71.7 cm for large salmon (Table 5). Comparable values for 1999 are 56.8 cm for small and 77.2 cm for large salmon. Comparable values for 2000 are 54.8 cm for small salmon and 79.1 cm for large salmon. In both 1997 and 1999, the percent female was very low at 17.6% in 1997 and 13.8% in 1999 for small salmon. For large salmon, it was 100% in 1997 and 83.3% in 1999 but the sample sizes are very low. In 2000, percent female in the samples was 13.7% for small salmon and 90.0% for large.

Accessible parr-rearing habitat

The estimate of 22,059 parr-rearing units for Big Brook is a minimum value as only the rearing areas of tributaries in the lower section of the river were included and pond area was not considered (Murphy 1973). Another source of error is that all linear distances were measured using 1:250,000 scale maps and were measured by hand-held planimeter. Comparison of habitat measured on 1:50,000 scale maps versus the 1:250,000 scale maps indicates that some habitat will be overlooked.

Conservation requirements

The estimated conservation requirements in eggs for Big Brook are as follows:

Fluvial Rearing Units: 22,059 (100 m^2)
Lacustrine Rearing Area: Not included

Standard Conservation Egg Deposition Requirements: Fluvial = 240 eggs per rearing unit

Egg Deposition Required for Conservation:

= Conservation egg requirements * Accessible parr rearing area

= 240 * 22,059

= 5,294,160 eggs

Total river returns, spawning escapement, and egg deposition

In 2000, the total river returns to Big Brook were estimated at 982 small and 151 large salmon after correction for non-operational periods and for mortalities in the angling fishery below the fence (Table 6). The retained angling catch in 2000 was 90 small and 11 large salmon and hook and releases were 123 small and 3 large salmon . Therefore, spawning escapement after correction for angling removals and hook and release mortalities was 878 small and 140 large salmon.

In 2000, egg deposition was estimated at 2,223,089 eggs which was 42% of the conservation requirements (Table 6). This estimate has several possible sources of error. First, although adjusted for, the counting fence was only operational for a 4-week period. Second, sample sizes used to derive biological characteristics are low, especially for sex ratios and some average values were used. Samples are adequate to define characteristics of the catch but were not taken over the entire run. Third, habitat measurements were determined from 1;250,000 scale charts and some tributary streams are not included in the survey which will to some degree under-estimate available habitat.

Analysis of risk

In determining egg deposition in the previous section, only the numbers of small and large salmon counted at the fence on Big Brook during the 4-week operational period in 2000 were known with certainty. If specific levels of variability are assumed for each input parameter and 5000 realizations made using a uniform distribution then Big Brook would not achieved 100% of conservation requirements at any level of variability (Figs. 3 & 4). At the 50^{th} percentile, 2,427,550 eggs were deposited which represents 46% of conservation requirement of 5,294,160 eggs based on the assumptions of the risk model. The corresponding 5^{th} and 95^{th} percentiles of the percentage of conservation requirement met varied from 35 to 58%. The high degree of variability is due to uncertainty in parameter values, in particular numbers of spawners and percent female.

Environmental data

Fig. 5 shows the daily mean water temperatures at the fence on Big Brook. Also shown are the maximum and minimum water temperatures from the fence site compared to the number of hooked and released small and large salmon for the angling fishery in 2000. Although on some days water temperatures exceeded 20 °C., it would appear from the low overall number of hooked and released salmon in relation to the days with higher water temperatures that mortalities are low compared to the population size.

DISCUSSION

In 2000, 982 small and 151 large salmon were estimated to have returned to Big Brook, Labrador. This is an increase of 24% and a decrease of 22% over the 790 small and 194 large salmon that returned in 1999.

Year	Small	Large	Total
1997	530	104	534
1999	790	194	984
2000	982	151	1,133

The conservation requirement of 5,294,160 eggs is the first established for a northern Labrador river continuing a process that began in 1990 (O'Connell and Dempson 1991). The calculated

percentage of 42% of the conservation requirement achieved is low; although it has increased from the 24% recorded in 1997. It is possible that in spite of adjusting the total returns for salmon entering during the non-operation of the counting fence that more salmon entered than were accounted for. If so, then the spawning escapement and percent of conservation requirement achieved would be an underestimate. However, given the low numbers of salmon entering otherwise would suggest that even if the actual number was underestimated, the percent conservation requirement achieved is still low as shown by the risk analysis. Because of the low returns in 2000 and the uncertainty in the estimates, it is recommended that the assessment be repeated in 2001 but the counting fence should be operated over the entire run. Also assessments should be conducted on other northern Labrador rivers. Some consideration should be given to verifying and if necessary refining the conservation requirements of 240 eggs per 100 m^2 for Labrador rivers. The standard conservation requirement for Atlantic Coast salmon was derived from rivers in the southern range of salmon distribution (Chaput MS 1997) and may be different for rivers in Labrador; especially where charr and sea trout are also present. Consequently, for Labrador it was decided to regard conservation requirements as a reference value only until some of the above considerations can be resolved.

Murphy (1973), using some very broad-based assumptions, estimated that Big Brook is capable of producing circa. 6600 salmon annually. As a result of the closure of the commercial fishery in 1998, most of the total population would return to the brook and spawn. An alternate method of examining stock status for Big Brook is to compare the numbers of salmon returning to the river versus those at Sand Hill River. When adjusted for the difference in drainage area (Big Brook - 793 km^2, Sand Hill – 1,276 km^2) gives 1,718 small and 353 large salmon for Big Brook if it were at the same average level of production as Sand Hill River was in 1994-96. The actual returns to Big Brook of 982 small and 151 large are 57% and 43% of the adjusted Sand Hill River returns. Ranger seals (*Phoca vitulina L.)* are known to overwinter and breed in the lower 10 km of this river and are likely predators on fish populations. It is possible that predation by seals and exploitation by man have reduced spawners to this level of production. In addition, salmon populations are known for their high degree of annual variability and it may be that the salmon returns to Big Brook in future will be higher.

Complete knowledge of exploitation patterns of fish stocks is important information for stock assessments. Because of a lack of assessments on northern and southern Labrador rivers, this information is generally lacking. For Big Brook in 2000, exploitation rates for the angling fishery were 9.2% on small retained salmon, 12.5% on small released salmon, 7.3% on large retained salmon and 2.0% on large released salmon. Exploitation rates are also available for Sand Hill River in southern Labrador (Reddin et al. 1995). In the early 1970s, average exploitation rates were 6% on small salmon and 2% on large salmon. In the 1990s, exploitation at Sand Hill had increased to 11% on retained small salmon and 4% on retained large salmon. For released salmon, exploitation rates were 14% on small salmon and 4% on large salmon. The level of removals in 2000 at Big Brook decrease the percentage of conservation requirements met by 12%.

O'Connell and Dempson (MS 1991) reported that there is evidence (unpublished) that atresia (the non-development and re-absorption of eggs) occurs to varying degrees in insular Newfoundland salmon. This phenomenon has also been reported in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet *et al.* 1984). Therefore, fecundity values measured from eggs in early stages of development (green eggs) should be regarded as potential values. Since calculations of conservation requirements and the percent of conservation requirements

achieved were based on green eggs, the occurrence of atresia in a given year on a particular river would increase the number of spawners required and decrease the percent of the requirements achieved. Also, fecundity values used to determine egg deposition in Big Brook were derived from Sand Hill River salmon.

In conclusion, this paper summarizes the stock status of the salmon population in Big Brook, Labrador. Although, there were several questions to be resolved it would appear that returns to Big Brook and the number of spawners were low in 2000; although they increased over 1997 and 1999 values. Assessments of rivers in SFA 1 should be continued in future years.

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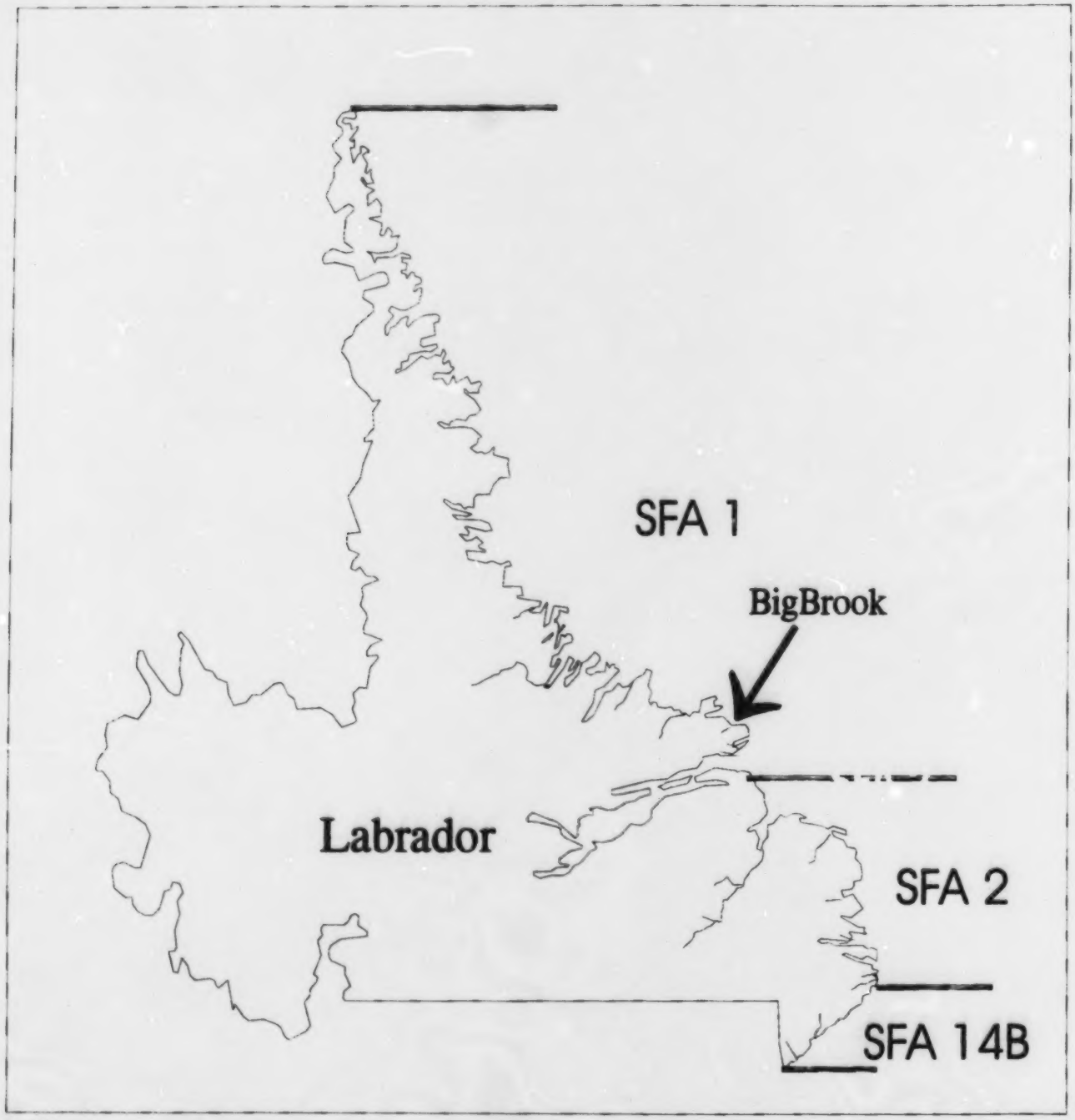
Fig. 1. Location map depicting Labrador, Salmon Fishing Areas (SFAs) and Big Brook.



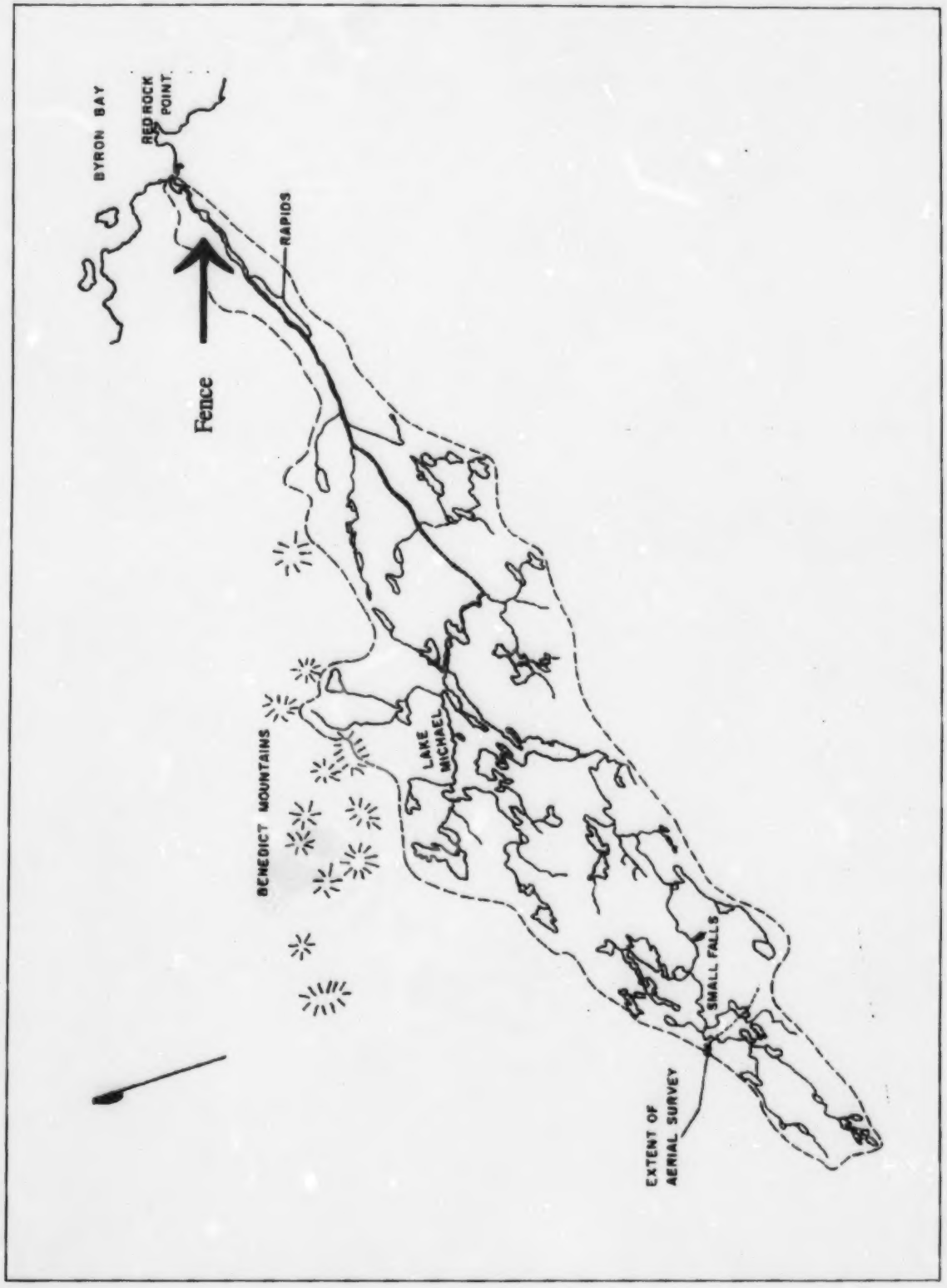


Fig. 2. Drainage basin for Big Brook, Labrador and location of fence site.

Fig.3 Results of risk analysis for egg deposition, Big Brook, 2000. Bottom panel is frequency count and top panel is probability distribution from 5000 realizations.

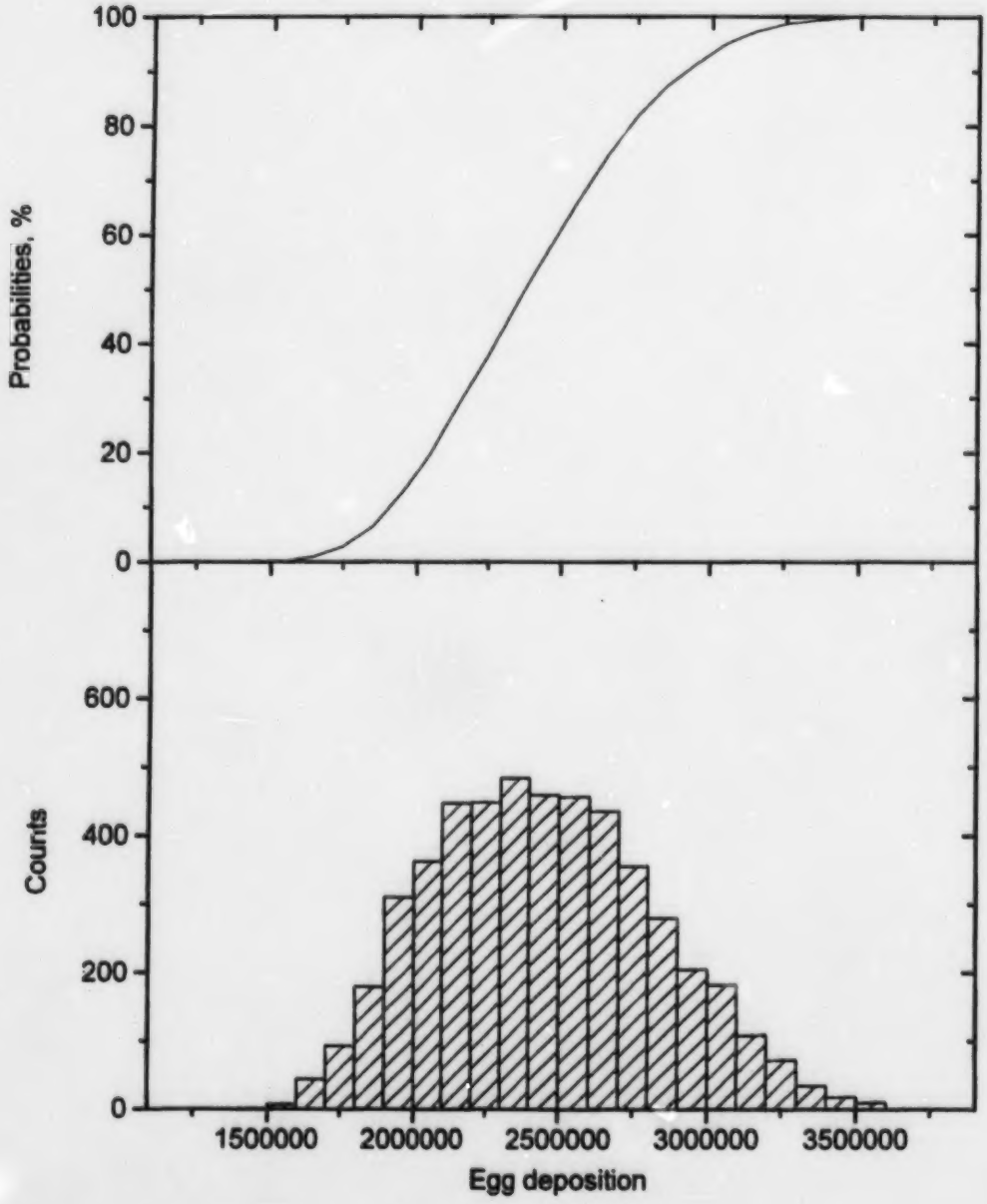


Fig.4 Results of risk analysis for the percent of conservation requirement met for Big Brook, 2000. Bottom panel is the frequency count and the top panel is the probability distribution from 5000 realizations.

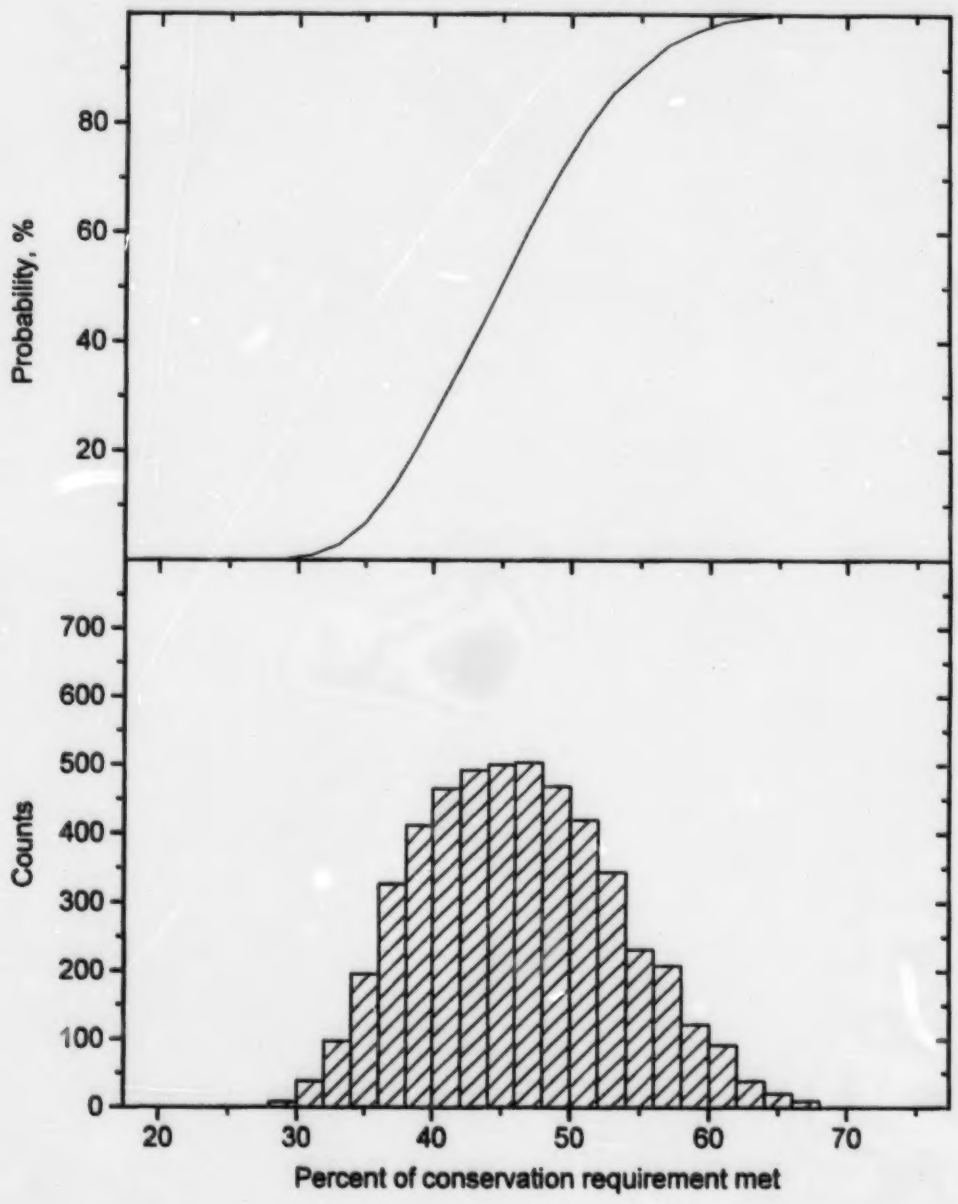


Fig. 5. Daily minimum and maximum water temperature (dashed lines) and numbers of hooked and released angled salmon (solid line) for Big Brook, 2000.

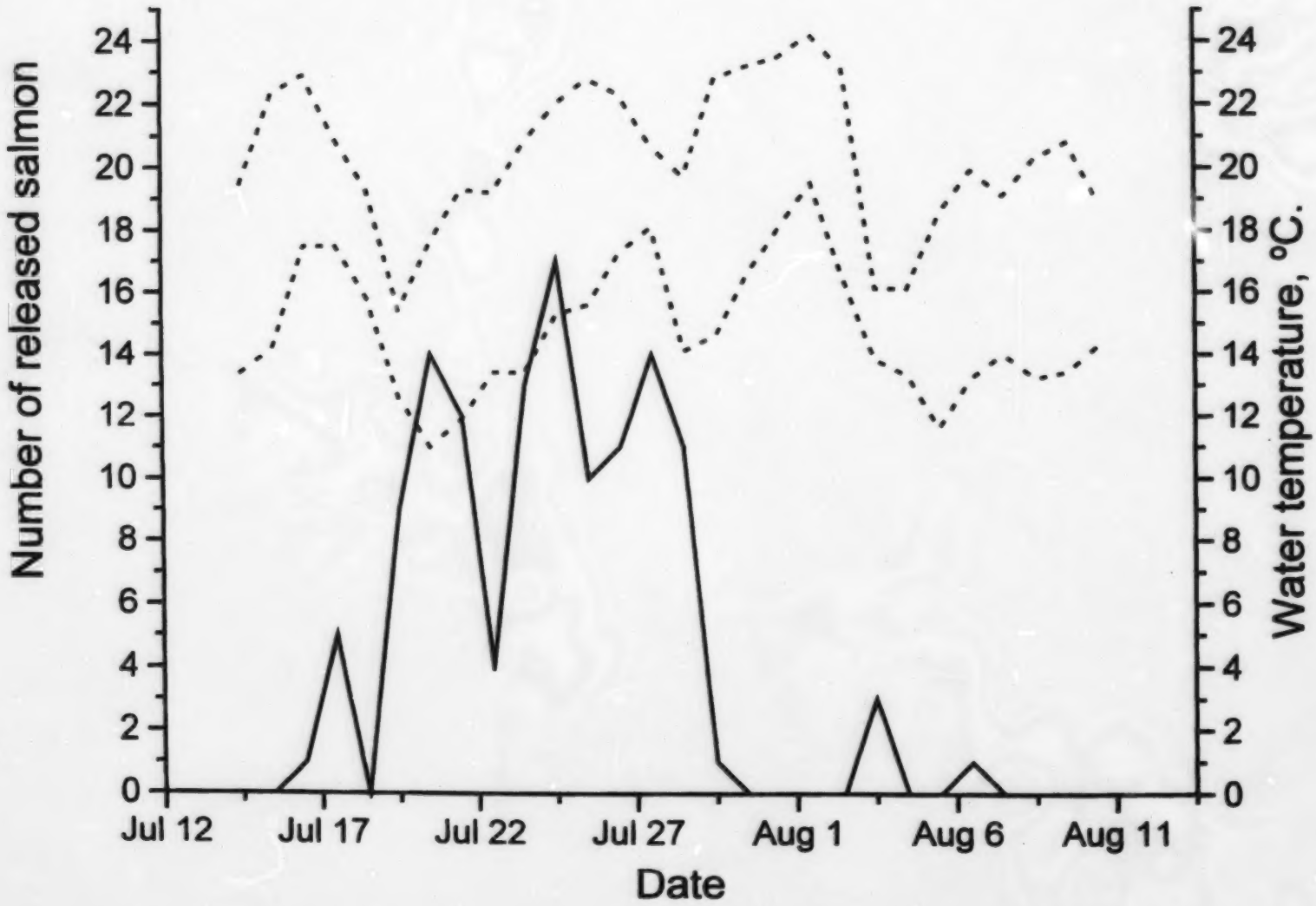


Table 1. DFO angling catch statistics for Big Brook, Labrador, 1974-2000.

Code: 5714280

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)				Proportion
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE	Large
1974	332	246	.	246	43	.	43	289	.	289	0.87	0.15
1975	.	.	.	.	.	.	.	.	.	.	.	.
1976	.	.	.	.	.	.	.	.	.	.	.	.
1977	.	.	.	.	.	.	.	.	.	.	.	.
1978	.	.	.	.	.	.	.	.	.	.	.	.
1979	266	310	.	310	107	.	107	417	.	417	1.57	0.26
1980	69	27	.	27	1	.	1	28	.	28	0.41	0.04
1981	.	.	.	.	.	.	.	.	.	.	.	.
1982	89	50	.	50	16	.	16	66	.	66	0.74	0.24
1983	69	20	.	20	1	.	1	21	.	21	0.30	0.05
1984	242	21	.	21	10	.	10	31	.	31	0.13	0.32
1985	.	.	.	.	.	.	.	.	.	.	.	.
1986	173	52	.	52	4	.	4	56	.	56	0.32	0.07
1987	56	37	.	37	6	.	6	43	.	43	0.77	0.14
1988	221	363	.	363	35	.	35	398	.	398	1.80	0.09
1989	298	412	.	412	46	.	46	458	.	458	1.54	0.10
1990	217	251	.	251	20	.	20	271	.	271	1.25	0.07
1991	455	79	.	79	7	.	7	86	.	86	0.19	0.08
1992	298	33	0	33	172	0	172	205	0	205	0.69	0.84
1993	.	.	.	.	.	.	.	.	.	.	.	.
1994	242	62	22	84	10	1	11	72	23	95	0.39	0.12
1995	152	92	21	113	5	0	5	97	21	118	0.78	0.04
1996	183	36	12	48	5	0	5	41	12	53	0.29	0.09
1997	427	73	32	105	2	1	3	75	33	108	0.25	0.03
1998	191	54	24	78	4	2	6	58	26	84	0.44	0.07
1999	92	49	41	90	13	9	22	62	50	112	1.22	0.20
2000**	166	90	123	213	11	3	14	101	126	227	1.37	0.06
84-89 X	198.0	177.0	.	177.0	20.2	.	20.2	197.2	.	197.2	0.9	0.1
95% CL	113.2	239.9	.	239.9	23.7	.	23.7	263.1	.	263.1	0.9	0.1
N	5	5	0	5	5	0	5	5	0	5	5	5
86-91 $\bar{X}$	236.7	199.0	.	199.0	19.7	.	19.7	218.7	.	218.7	0.6	0.2
95% CL	139.8	173.9	.	173.9	18.3	.	18.3	191.9	.	191.9	0.7	0.4
N	6	6	0	6	6	0	6	6	0	6	6	6
92-96 $\bar{X}$	218.8	55.8	13.8	69.5	48.0	0.3	48.3	103.8	14.0	117.8	0.5	0.3
95% CL	160.7	68.2	25.4	89.5	205.5	1.2	205.1	177.1	26.1	159.2	0.6	0.9
N	3	3	3	3	3	3	3	3	3	3	3	3

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.
CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 1996 AND ON RETAINED FISH ONLY PRIOR TO 1992.
**PRELIMINARY

Table 2. Daily counts of upstream migrating Atlantic salmon at Big Brook (Michaels River), Labrador in 2000. Fence in operation from July 16, 2000 to August 12, 2000.

	Number of fish		Cumulative numbers			Cumulative percentages			% large
DATE	SMALL	LARGE	SMALL	LARGE	TOTAL	SMALL	LARGE	TOTAL	salmon
16 July	0	0	0	0	0	0.0	0.0	0.0	
17 July	0	0	0	0	0	0.0	0.0	0.0	
18 July	2	0	2	0	2	0.3	0.0	0.3	0
19 July	2	2	4	2	6	0.6	1.8	0.8	50
20 July	0	0	4	2	6	0.6	1.8	0.8	
21 July	0	1	4	3	7	0.6	2.7	1.0	100
22 July	0	0	4	3	7	0.6	2.7	1.0	
23 July	0	0	4	3	7	0.6	2.7	1.0	
24 July	0	0	4	3	7	0.6	2.7	1.0	
25 July	2	0	6	3	9	1.0	2.7	1.2	0
26 July	37	4	43	7	50	6.9	6.4	6.8	10
27 July	2	0	45	7	52	7.2	6.4	7.1	0
28 July	16	5	61	12	73	9.8	10.9	9.9	24
29 July	1	1	62	13	75	9.9	11.8	10.2	50
30 July	0	0	62	13	75	9.9	11.8	10.2	
31 July	21	4	83	17	100	13.3	15.5	13.6	16
1 August	45	4	128	21	149	20.5	19.1	20.3	8
2 August	2	1	130	22	152	20.8	20.0	20.7	33
3 August	164	29	294	51	345	47.0	46.4	46.9	15
4 August	74	14	368	65	433	58.9	59.1	58.9	16
5 August	86	17	454	82	536	72.6	74.5	72.9	17
6 August	52	10	506	92	598	81.0	83.6	81.4	16
7 August	48	8	554	100	654	88.6	90.9	89.0	14
8 August	26	3	580	103	683	92.8	93.6	92.9	10
9 August	23	4	603	107	710	96.5	97.3	96.6	15
10 August	16	2	619	109	728	99.0	99.1	99.0	11
11 August	0	0	619	109	728	99.0	99.1	99.0	
12 August	6	1	625	110	735	100.0	100.0	100.0	14
Total	625	110							15

Table 3. Biological characteristic data for Big Brook (Michaels River), Labrador, 2000.

Class	Type	Fork length (cm)	Whole weight (kg)	Gutted weight(kg)	Female Percent	Female Number		River age distribution 1	2	3	4	5	6	7	Total
Small salmon	Mean	54.8	1.95	1.57	14	7(51)	Number	0	0	4	14	7	9	0	34
	SD	2.68	0.07	0.23			Percent	0	0	12	41	21	26	0	100
	N	65	2	58											
Large salmon	Mean	79.1	4.89	4.42	90	9(10)	Number	0	0	1	1	4	1	0	7
	SD	4.42	0.79	0.95			Percent	0	0	14	14	57	14	0	100
	N	10	4	9											
Grilse	Mean	55.2	1.95	1.59	24	7(29)	Number	0	0	4	14	7	9	0	34
	SD	2.56	0.07	0.2			Percent	0	0	12	41	21	26	0	100
	N	36	2	34											
2SW	Mean	78.3	4.89	4.26	88	7(8)	Number	0	0	1	1	4	1	0	7
	SD	2.93	0.79	0.63			Percent	0	0	14	14	57	14	0	100
	N	8	4	7											
Repeat spawners	Mean	NA	NA		0	0	Number	0	0	0	0	0	0	0	0
	SD	NA	NA				Percent								
	N	0	0												
All salmon	Mean	58.0	3.91	1.96	26	16(61)	Number	0	0	5	15	11	10	0	41
	SD	8.82	1.63	1.05			Percent	0	0	12	37	27	24	0	100
	N	75	6	67											

Table 4. River age distribution for Big Brook, Labrador in 1997 and 1999-2000.

Year	Size		River age distribution 1	2	3	4	5	6	7	Total
1997	Small	Number	0	0	2	7	21	34	0	64
		Percent	0	0	3	11	33	53	0	100
	Large	Number	0	0	0	0	3	0	0	3
		Percent	0	0	0	0	100	0	0	100
1999	Small	Number	0	0	0	3	30	0	1	34
		Percent	0	0	0	9	88	0	3	100
	Large	Number	0	0	0	6	5	3	0	14
		Percent	0	0	0	43	36	21	0	100
2000	Small	Number	0	0	4	14	7	9	0	34
		Percent	0	0	12	41	21	26	0	100
	Large	Number	0	0	1	1	4	1	0	7
		Percent	0	0	14	14	57	14	0	100
All	Both	Number	0	0	7	31	70	47	1	156
		Percent	0	0	4	20	45	30	1	100

Table 5. Biological characteristics of male and female salmon used for the assessment.

Class	Year	Type	Fork length (cm)	Whole weight (kg)	Percent female[1]
Small	1997	Mean	54.0	1.75	17.6
		SD	2.440	0.292	
		N	68	67	68
	1999	Mean	56.8	2.11	13.8
		SD	1.650	0.287	
		N	38	14	29
	2000	Mean	54.8	1.95	13.7
		SD	2.680	0.070	
		N	65	2	51
Large	1997	Mean	71.7	3.93	100.0
		SD	3.470	0.322	
		N	3	3	2
	1999	Mean	77.2	5.08	83.3
		SD	4.320	0.428	
		N	16	10	12
	2000	Mean	79.1	4.89	90.0
		SD	4.420	0.790	
		N	10	4	10

[1] default values for proportion female used in assessment were 0.5 for small and 0.8 for large from Sand Hill River, 1994-96.

Table 6. Adult salmon returns, spawning escapment and egg depositions for Big Brook, Labrador in 1997 & 1999-2000.

SPAWNING ESCAPEMENT $SE = TRR - (AC) - (HRM), HRM = (HRC * 0.1)$

SE= Spawning escapment
TRR= Total returns to river (FC + ACb + HRMb)
FC= Fence count
AC= Angling catch (retained)
HRC= Hook & release catch
HRMf= Hook & release mortalities evaluated as 10% of HRC (HRC * 0.10)
a & b= subscripts denoting above and below the counting fence

Factor	Size	1997	1999	2000	Average
TRR	Small	530	790	982	767
	Large	104	194	151	150
ACa	Small	0	0	2	1
	Large	0	0	0	0
HRCa	Small	0	0	1	0
	Large	0	0	0	0
ACb	Small	73	49	90	71
	Large	2	13	11	9
HRCb	Small	32	41	123	65
	Large	1	9	3	4
SE	Small	454	737	878	689
	Large	102	180	140	141

EGG DEPOSITION $ED = SE * PF * RF * FL$

ED= Egg deposition
SE= Spawning escapment
PF= Proportion females
RF= Relative fecundity (eggs/cm)
FL= Mean fork length of female salmon

Factor	Size	1997	1999	2000	AVERAGE
SE	Small	454	737	878	689
	Large	102	180	140	141
PF	Small	0.5	0.5	0.5	0.500
	Large	0.8	0.8	0.8	0.800
RF[1]	Small	68.2	68.2	68.2	68.2
	Large	67.5	67.5	67.5	67.5
FL	Small	54.0	56.8	54.8	55.2
	Large[2]	77.3	77.3	77.3	77.3
ED	Small	835627	1427287	1639954	1300956
	Large	425351	751773	583136	586753
Total		1260978	2179060	2223089	1887709
Conservation requirements		5294160	5294160	5294160	5294160
% requirements met		24	41	42	36

[1] *in the absence of fecundity values for Big Brook, Sand Hill River values were used*
[2] *due to low sample sizes mean fork lengths from 1997 & 1999 were used*